CLAIMS

What is claimed is:

1. A method for determining an orientation of an object, the method comprising:

acquiring an intensity image of the object;

generating at least a portion of a two-dimensional frequency response of the intensity image;

representing the at least a portion of a two-dimensional frequency response within a frequency space, the at least a portion of a frequency response providing features arranged in a spatial-frequency pattern within the frequency space; and

finding an orientation of the spatial-frequency pattern within the frequency space, thereby providing the orientation of the object.

2. The method of claim 1, wherein the intensity image is of a portion of the object.

3. The method of claim 1, wherein generating further includes:

generating at least a portion of a two-dimensional frequency response of the intensity image by applying a frequency analysis tool to the intensity image.

4. The method of claim 3, wherein generating the at least a portion of a two-dimensional frequency response of the intensity image includes:

generating at least a portion of a magnitude of a two-dimensional discrete Fourier transform of the intensity image to provide the at least a portion of a two-dimensional frequency response.

5. The method of claim 4, wherein the two-dimensional discrete Fourier transform includes a two-dimensional discrete fast Fourier transform.

6. The method of claim 3, wherein generating the at least a portion of a two-dimensional frequency response of the intensity image includes:

generating at least a portion of a two-dimensional discrete cosine-transform of the intensity image to provide the at least a portion of a two-dimensional frequency response.

7. The method of claim 3, wherein generating the at least a portion of a two-dimensional frequency response of the intensity image includes:

generating at least a portion of a two-dimensional discrete sine-transform of the intensity image to provide the at least a portion of a two-dimensional frequency response.

8. The method of claim 3, wherein generating the at least a portion of a two-dimensional frequency response of the intensity image includes:

generating at least a portion of a two-dimensional z-transform of the intensity image to provide the at least a portion of a two-dimensional frequency response.

9. The method of claim 1, wherein representing further includes:

representing the at least a portion of a two-dimensional frequency response as a logarithmically scaled frequency response within the frequency space.

10. The method of claim 1, wherein the frequency space is a frequency image, and wherein representing the at least a portion of a two-dimensional frequency response further includes:

scaling the at least a portion of a two-dimensional frequency response using a scaling function so as to enhance high frequency responses within the at least a portion of the two-dimensional frequency response to provide a scaled frequency response; and

mapping the scale response by gray scale on the frequency image.

11. The method of claim 1, wherein finding further includes:

applying an angle finding means to the frequency space to provide an angle of the spatial-frequency pattern.

12. The method of claim 1, wherein finding further includes:

identifying the spatial-frequency pattern within the frequency space; and

finding the orientation of the spatial-frequency pattern.

13. The method of claim 1, wherein the at least a portion of a two-dimensional frequency response provides features forming a plurality of spatial-frequency patterns within the frequency space, and wherein finding further includes:

finding the orientation of the plurality of spatial-frequency patterns.

14. The method of claim 1, wherein the at least a portion of a two-dimensional frequency response provides features forming a plurality of spatial-frequency patterns within the frequency space, and wherein finding further includes:

identifying one dominant spatial-frequency pattern from among the plurality of spatial-frequency patterns; and

finding the orientation of the dominant spatial-frequency pattern.

15. The method of claim 14, wherein identifying further includes:

identifying as the dominant spatial-frequency pattern one spatial-frequency pattern of the plurality of spatial-frequency patterns that includes a greatest number of the features.

16. The method of claim 1, wherein the orientation is at a constant offset from the orientation of the spatial-frequency pattern.

17. The method of claim 16, wherein the constant offset substantially equals zero.

18. The method of claim 16, wherein the orientation of the object is defined by an orientation angle of a feature on the object.

19. The method of claim 1, wherein the spatial-frequency pattern includes a line, the line having a line angle, and wherein the orientation of the object is an object angle, the object angle having a constant offset from the line angle.

20. The method of claim 19, wherein the object is a leaded object having leads, and wherein the orientation of the leaded object is defined by an orientation angle of one of the leads.

21. The method of claim 19, wherein the object angle substantially equals an orientation angle of a surface mount object from an axis of the intensity image.

22. The method of claim 1, further comprising:

inputting the orientation of the object into a subsequent image processing algorithm.

23. A method for determining an orientation of an object, the method comprising:
acquiring an intensity image of the object;
generating at least a portion of at least a two-dimensional frequency response of the intensity image, frequencies within the at least a portion of at least a two-dimensional frequency response forming a spatial-frequency pattern;
finding an orientation of the spatial-frequency pattern, thereby providing the orientation of the object.

24. The method of claim 23, wherein generating further includes:
representing the at least portion of at least a two-dimensional frequency response within a frequency space, features within the frequency space forming the spatial-frequency pattern.

25. The method of claim 24, wherein the frequency space is a frequency image, and wherein representing the at least a portion of at least a two-dimensional frequency response further includes:
scaling the at least a portion of at least a two-dimensional frequency response using a scaling function so as to enhance high frequency responses within the at least a portion of the two-dimensional frequency response to provide a scaled frequency response; and
mapping the scale response by gray scale on the frequency image.

26. The method of claim 23, wherein generating further includes:
generating at least a portion of at least a two-dimensional frequency response of the intensity image by applying a frequency analysis tool to the intensity image.

27. The method of claim 26, wherein generating the at least a portion of at least a two-dimensional frequency response of the intensity image includes:

generating at least a portion of a magnitude of at least a two-dimensional discrete Fourier transform of the intensity image to provide the at least a portion of at least a two-dimensional frequency response.

28. The method of claim 23, further comprising:

acquiring a plurality of intensity images of the object at different depths within the object; and

generating a three-dimensional image containing a three-dimensional intensity representation of the object using the plurality of intensity images of the object;

wherein generating the at least a portion of at least a two-dimensional frequency response of the intensity image further includes:

generating at least a portion of a three-dimensional frequency response by applying a frequency analysis tool to the three-dimensional image.

29. The method of claim 23, wherein the orientation of the object in the intensity image is at a constant offset from the orientation of the spatial-frequency pattern in the frequency space.

30. The method of claim 29, wherein the orientation of the object is defined by an orientation angle of a feature on the object.

31. The method of claim 23, wherein the spatial-frequency pattern includes a line, the line having a line angle, and wherein the orientation of the object is an object angle, the object angle having a constant offset from the line angle.

32. An apparatus for determining an orientation of an object within an intensity image, the apparatus comprising:

frequency means adapted to generate at least a portion of at least a two-dimensional frequency response of the intensity image;

a frequency space adapted to receive the at least a portion of at least a two-dimensional frequency response, the at least a portion of a frequency response providing features arranged in a spatial-frequency pattern within the frequency space; and

finding means adapted to find an orientation of the spatial-frequency pattern within the frequency space, thereby providing the orientation of the object.

33. The apparatus of claim 32, wherein the frequency means is further adapted to generate at least a portion of at least a two-dimensional frequency response of the intensity image by applying a frequency analysis tool to the intensity image.

34. The apparatus of claim 33, wherein the frequency means is further adapted to generate at least a portion of a magnitude of at least a two-dimensional discrete Fourier transform of the intensity image to provide the at least a portion of at least a two-dimensional frequency response.

35. The apparatus of claim 32, wherein the frequency space is a frequency image, the apparatus further comprising:

scaling means, adapted to scale the at least a portion of at least a two-dimensional frequency response on the frequency space using a scaling function so as to enhance high frequency responses within the at least a portion of the two-dimensional frequency response and to provide a scaled frequency response; and

mapping means, in cooperation with the scaling means, adapted to map the scaled frequency response by grey scale on the frequency image.

36. The apparatus of claim 32, wherein the orientation of the object in the intensity image is at a constant offset from the orientation of the spatial-frequency pattern in the frequency space.

37. The apparatus of claim 36, wherein the orientation of the object is defined by an orientation angle of a feature on the object.

38. The apparatus of claim 32, wherein the spatial-frequency pattern includes a line, the line having a line angle, and wherein the orientation of the object is an object angle, the object angle having a constant offset from the line angle.

39. A method for finding an orientation of an object, the method comprising:

acquiring an intensity image of the object;

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applying a frequency analysis tool to the intensity image to produce at least a portion of a two-dimensional frequency response of the intensity image;

representing the at least a portion of a two-dimensional frequency response within a frequency space, the at least a portion of a frequency response providing features arranged in spatial-frequency pattern within the frequency space; and

determining an orientation of the spatial-frequency pattern to provide the orientation of the object.

40. The method of claim 39, wherein applying the frequency analysis tool includes:

generating at least a portion of a magnitude of a two-dimensional discrete Fourier transform of the intensity image to provide the at least a portion of a two-dimensional frequency response.

41. The method of claim 39, wherein the frequency space is a frequency image, and wherein representing the at least a portion of a two-dimensional frequency response further includes:

scaling the at least a portion of a two-dimensional frequency response using a scaling function so as to enhance high frequency responses within the at least a portion of the two-dimensional frequency response to provide a scaled frequency response; and

mapping the scale response by gray scale on the frequency image.

42. The method of claim 39, wherein the orientation of the object in the intensity image is at a constant offset from the orientation of the spatial-frequency pattern in the frequency space.

43. The method of claim 42, wherein the orientation of the object is defined by an orientation angle of a feature on the object.

44. The method of claim 39, wherein the spatial-frequency pattern includes a line, the line having a line angle, and wherein the orientation of the object is an object angle, the object angle having a constant offset from the line angle.